# VETRONICS Technology Testbed (VTT) Case Study

## US ARMY Tank-Automotive Research,

## Development and Engineering Center (TARDEC)

### Objective of Case Study

The Vehicle Electronics (VETRONICS) organization within TARDEC developed the VETRONICS Open System Architecture (VOSA) model, which is the VETRONICS implementation of the Department of Defense (DOD) Technical Reference Model (TRM) concept.

The goal of VOSA is to address open system architecture concerns for ground platform systems using both commercial and military standards and to incorporate the standards identified by VOSA into the Joint Technical Architecture – Army document. VOSA has identified standard software/hardware interfaces, which facilitate interoperability; technology upgrades; reduced software development time; maximizes portability; and coordinates the sharing of resources.

This case study will show how TARDEC developed, as a research and development project, a new weapon system concept, the VETRONICS Technology Testbed (VTT), using the DOD TRM as the basis for the architectural design. VOSA via DOD TRM use interface classes to define the relationship between entities within a weapon system, and VETRONICS used VOSA to define the entity relationships within the VTT.

### System Overview

The VTT is a research and development project within TARDEC being sponsored by the Office of the Deputy Assistant Secretary for Research and Technology, Dr. A. Michael Andrews. The VTT requirements were generated from the Office of the Deputy Assistant Secretary for Research and Technology and the user (soldier). The VTT (figure 1) is a ruggedized, real-time hardware and software module system being integrated into an actual ground combat host vehicle. The main objective of the VTT is to demonstrate the capability of one crewmember to perform the functions of both the vehicle Commander and vehicle Driver. The VTT will also be one of the beta test sites for the Weapon Systems Technical Architecture (WSTA) Operating Environment (OE). The demonstration must take place while operating over military significant terrain and while performing a military significant mission.

Vehicle requirements will include:

- Tracked Vehicle
- 20 – 40 Ton Weight Class
- Two Crewmembers (Commander/Driver and Gunner)
- Drive-By-Wire Capability
- Day and Night Operation
- Indirect Vision as Primary Vision
- Three Dimensional (3D) Audio System

- Speech Recognition and Generation
- Head Tracking
- Multi-Function Displays with Touch Screens
- Baseline Crewman's Associate Soldier Machine Interface (SMI)
- Embedded Simulation as an Enabling Technology for Embedded Training, Mission Rehearsal, Battlefield Visualization and After Action Review
- Compatibility with Joint Technical Architecture (JTA)-Army and Weapon System Technical Architecture Working Group (WSTAWG) mandates
- WSTAWG Operating Environment (OE)
- FBCB2 Interoperability (Embedded Battle Command (EBC) and Joint Variable Message Format (JVMF))
- Communication viaVoice Intercom and SINCGARS Radios
- Data Logging/Test Observation is Required
- Vehicle Safety Release/Safety Driver

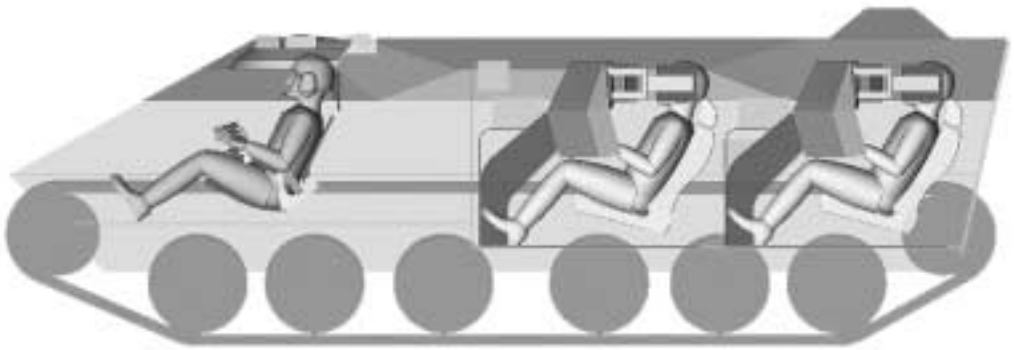

**Figure 1**

## Description/Process Used

VOSA defines the open system standards needed for the ground combat weapon system. The VOSA architecture process is an iterative process involving studies of legacy systems, industrial standards and commercial standards that meet the Technical Architecture and performance requirements for the combat weapon system. This architectural iterative process involves studying cost factors, performance risks, and performance with respect to interoperability. The VTT is being simulated in a laboratory environment for preliminary testing, and the software used in this simulation testing will be installed on the vehicle for ground vehicle testing. VETRONICS is achieving software reuse by porting software from the Systems Integration Laboratory (SIL) to the combat vehicle.

System Level Architecture. The VETRONICS system of a combat vehicle (figure 2) shall consist of stations interconnected by data, audio, and a video distributed network all powered by a

distributed power network. The components that make up the software architecture (figure 3) are identified by name with data flow direction via data buses identified in table 1. An example of the software data type definitions used that provide for software interoperability between layers and plug and play capabilities are shown in table 2.

To help us refine the architecture for the VTT, we identified the services and the interface classes within our standards using the DOD TRM guidance document (table 1). By using this table, the system interfaces and services can be categorized, assessed and compared for commonality, portability, and interoperability issues.

**Figure 2**

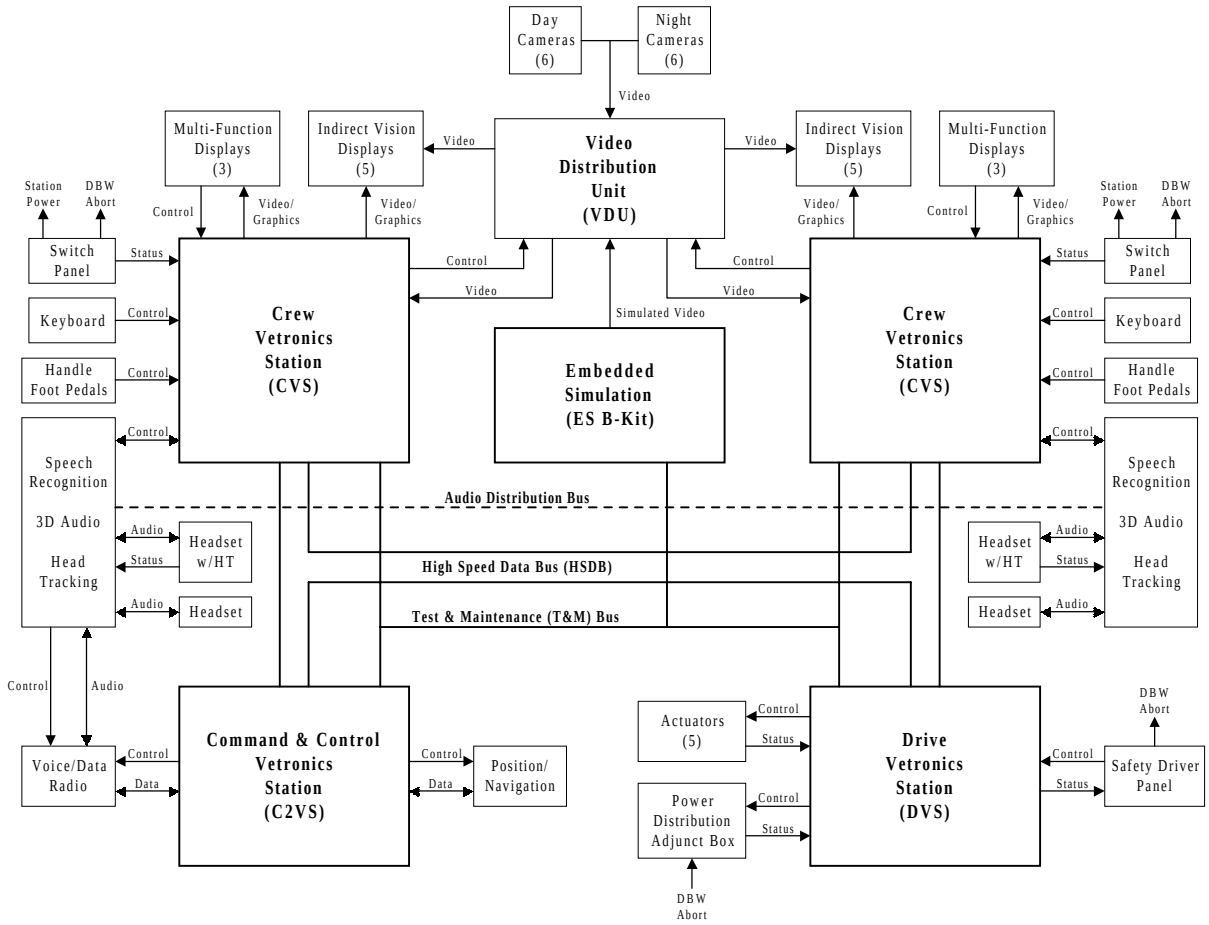

**Table 1**

| **VETRONICS TECHNOLO-GIES TESTBED March 2000** | | | **Joint Technical Architecture (JTA)**<br><br>**Version 3.0 15 November 1999** |
|---|---|---|---|
| **(Draft) Interface Definition** | **Standard** | **Description** | **Paragraph** |
| | | | |
| | | | |
| 1D | EIA 232 | Serial Data Link | **2.3.2.2.2.2** |
| 1D | EIA 423 | Serial Data Link | **2.3.2.2.2.2** |
| 1D | EIA 422 | Serial Data Link | **2.3.2.2.2.2** |
| 1D | MIL-STD-1275 | Characteristics of 28 Volt DC Electrical Systems in Military Vehicles | |
| 1D | MIL-STD-1474 | Noise Limits for Army Materiel | |
| 1D | MIL-STD-461 | Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility | |
| 1D/1L | SVME-179 | General Purpose Processors (GPP) PowerPC | |
| 1D/1L | IEEE 802.3/80214 | CSMA/CD, 10/100BASE-T | **2.3.2.2.2.1** |
| 1D/1L | | ATM: Asynchronous Transfer Mode | **2.3.2.2.2.5** |
| 1D/1L | Dual Pentium III 500mhz | Processors B-Kit | |
| 1D/1L | RT-1523(E) | Receiver-Transmitter (ASIP) | |
| 1D/1L | AS-3916 | Antenna | |
| 1D/1L | IEEE 1014 Rev D | VME64 (VME Extension) | **WS.GV.3.5.2** |
| 1D/1L | ANSI X3.131 | Small Computer Serial (System) Interface | **WS.GV.3.5.2** |
| 1D/1L | MIL-STD-1553B | Digital Time Division Command/Response Multiplex | **WS.GV.3.5.2** |
| 1D/1L | IEEE P1386-1 | PCI Mezzanine | **WS.3.5.3** |
| 1D/1L | EIA 170 | RS-170 Monochrome Video | |

| | | | |
|---|---|---|---|
| 1D/1L | SMPTE 170M | NTSC Color Video | |
| 1D/1L | IEEE 1102.2 (IEEE 1101.2) | Mechanical core specifications for conduction cooled eurocards | **WS.GV.3.5.2** |
| 1D/1L | ISO/IEC 8802-3 | Ethernet | |
| 1D/1L | ICD-GPS-153 | PLGR GPS ICD (Emerging Standards) | |
| 1D/1L | EIA 485 | Multi-Drop Bus | - |
| 1D/1L | SAE AS 4075 | High Speed Ring Bus | - |
| 1D/1L | ANSI X3T10/11 | Fibre Channel | **C4ISR.3.2.2.2.1** |
| 1D/1L | | CSMA/CD, 10/100BASE-F | - |
| 1D/1L | IEEE 1014 | Versa Module Europe (VME) | **WS.GV.3.5.2** |
| 1D/1L | | Universal Serial Bus (USB) | - |
| 1D/1L | IEEE 1394 (Firewire) | IEEE standard for a high performance bus | **C4ISR.3.2.2.2.2** |
| 1D/1L | IEEE 1014-1987 "Versa Module Europe (Eurocard)" (VME) | Commercial backplane control bus for high performance systems | **WS.GV.3.5.2** |
| 1D/1L | IEEE P1386-1 | PCI Mezzanine card standard | **WS.3.5.3** |
| 1D/1L | VITA 20-199x Draft 1.6 | Conduction cooled PCI mezzanine card standard | - |
| 1D/1L | VITA 18-199x Draft | VME pin assignments for format E form factor SEM boards and backplanes | - |
| 1D/1L | ISO 11898 | Controller Area Network (CAN) Bus | - |
| 1D/1L | | Peripheral Component Interconnect (PCI) | **C4ISR.CRY.3.2.1** |
| 1D/1L | | Compact PCI | **WS.GV.3.5.2** |
| 1D/1L | ANSI X3T10/11 | Fibre Channel | **C4ISR.3.2.2.2.1** |
| 1D/1L | ISO 11898 | Road Vehicle - Interchange of Digital Information - Controller Area Network (CAN) for High Speed Communication (power management) | - |
| 1D/1L | ATR | PCB format | - |

| | | | |
|---|---|---|---|
| 1D/1L | IEEE 1101.4a<br>Military Format-E<br>Form Factor<br>Modules | PCB format<br>EIA E700AAXA 372 pin connector | - |
| 2D | AM-7239(E) | Vehicular Amplifier Adapter w/INC | |
| 2D | AM-7238 | RF Amplifier | |
| 2L | VESA PnD | Display monitor plug & display | - |
| 3L | MIL-STD-1777<br>(RFC 791) | Internet Protocol (IP) | **2.3.2.1.1.2.1.3** |
| 3L | (RFC 768) | User Data (Datagram) Protocol (UDP) | **2.3.2.1.1.2.1.2** |
| 3L | ISO/IEC 9945<br>IEEE 1003 | Information Technology - Portable Operating System Interface (POSIX) | **2.2.2.2.1.7** |
| 3L | IETF Standard 51<br>(PPP) | Point to Point Standards | |
| | | | |
| 3L | VMF TIDP (VMF) | Data Exchange | |
| 3L | X.500 | Directory Services | **2.3.2.1.1.1.2.1** |
| 3L | | Simple Network Management Protocol (SNMP) | **2.3.2.4.1** |
| 3L | (RFC 959) | File Transport Protocol (FTP) | **2.3.2.1.1.1.3** |
| 3L | MIL-STD-1778<br>(RFC 793) | Transmission Control Protocol (TCP) | **2.3.2.1.1.2.1.1** |
| 3L | | Express Transport Protocol (XTP) | - |
| 3L | ITU-R BT.601 | Studio encoding parameters for digital television for standard 4:3 and widescreen 16:9 aspect ratio | **2.2.2.2.1.4.5.1.1** |
| 3L | ITU-R BT.1302 | Interfaces for digital component video signals in 525-line and 625-line television systems operating at the 4:2:2 level of recommendation ITU-R BT.601 | - |
| 3L | | Asynchronous Transfer Mode (ATM) | **2.3.2.2.2.5** |
| 3L | ITU-R BT 472 | Video frequency characteristics for 625-line colour or monochrome television systems | - |

| | | | |
|---|---|---|---|
| 3L | ISO/IEC 13818 (MPEG2) | Information technology - Generic coding of moving pictures and associated audio information | **2.2.2.2.1.4.5.1.1** |
| 3L | VESA XVGA | Extended VGA display monitor timing | - |
| 3L | VESA SVGA | Super VGA display monitor timing | - |
| 3L | | X-Window System | **2.2.2.2.1.2** |
| 3L | (IEEE 1295) | Motif graphical user interface development toolkit | **2.2.2.2.1.2** |
| 3L/1D/1L | DY4 DMV-177 | the EBC common card processor | |
| 4D | | X-Window System | **2.2.2.2.1.2** |
| 4D/3D/3L/2D/2L Operating System Service | | VxWorks | - |
| 4D/3D/3L/2D/2L Operating System Service | | LynxOS | - |
| 4D/3X/3L Support System Service | WSTAWG #1 | WSTAWG Operating Environment (OE) Application Programmer's Interface (API) | |
| 4L | MIL-STD-2401 (WGS 84 Datum) | Geospatial Data Interchange | |
| 4L | MIL-STD-2525a | Common Warfighting Symbology | **2.5.2.3** |
| 4L | WSTAWG #2 | WSTAWG Weapon System Mapping Services API | |
| 4L | FBCB2 | Force XXI Battle Command Brigade and Below | |
| 4L | WSTAWG | Position and Navigation (Pos/Nav) API | |
| 4L | | Hypertext Transfer Protocol (HTTP) | **2.3.2.1.1.1.8.1** |
| 4L | ISO/IEC 14496 (MPEG4) | Coding of moving pictures & audio | - |
| 4L | WSTAWG JVMF | Joint Varible Message Parser API | |
| Software Engineering Service | ISO/IEC 8652 | Programming Language Ada | **Not Mandated** |
| Software Engineering Service | ISO/IEC 9899 | Programming Language C | - |

| | | | |
|---|---|---|---|
| Software Engineering Service | ISO/IEC 14882 | Programming Language C++ | - |
| Software Engineering Service | ISO 12207 | Software Development and Documentation | |
| Service | MIL-STD-882 | System Safety Program Requirements | |
| Service | MIL-STD-1472 | Human Engineering Design Criteria for Military Systems, Equipment and Facilities | |
| Service | MIL-HDBK-759 | Human Factors Engineering Design for Army Materiel | |
| Service | MIL-STD-1815 | Reference Manual for the Ada Programming Language. | |
| Service | MIL-STD-1275 | Characteristics of 28 volt dc Electrical Systems in Military Vehicles | - |
| Service | MIL-STD-704 | 270V dc Aircraft Electrical Power Requirements<br>Includes 270 volt systems | - |
| Service | To be defined | 600 volt systems | - |
| Service | ISO/IEC 12207 | Software lifecycle processes | - |
| Service | IEEE/EIA 12207 | Industry Implementation of ISO/IEC 12207 | - |
| Service | J-STD-016 | Software lifecycle processes, software development | - |
| Service | n/a | JAVA | **2.2.3.4.2 (JVM)** |
| Service | n/a | CORBA | **2.2.2.2.1.11.2** |
| Service | JSP 101 | Security | - |
| Service | ISO/IEC 7498-1 | Information Technology - Open Systems Interconnection - Basic Reference Model: The Basic Model | - |
| Service | ISO/IEC 8822 | Information Technology - Open Systems Interconnection - Presentation Service Definition | - |
| Service | ISO/IEC 10746 (various parts) | Information Technology - Basic Reference Model of Open Distributed Systems | - |
| Service | AS 4893 | Generic Open Architecture (GOA) Framework | **WS.3.1** |

| | | | |
|---|---|---|---|
| Service | ISO/IEC 8824-2 | Information Technology - Abstract Syntax Notation One (ASN.1): Information Object Specification | - |
| Service | ISO/IEC 8825-2 | Information Technology - ASN.1 Encoding Rules: Specification of Packet Encoding Rules (PER) | - |
| Communication Service<br>3L | MIL-STD-188-220B | Combat Net Radio Networking | |
| Service | (IEEE 1295) | Motif graphical user interface development toolkit | **2.2.2.2.1.2** |

**Software Architecture (figure 3)**

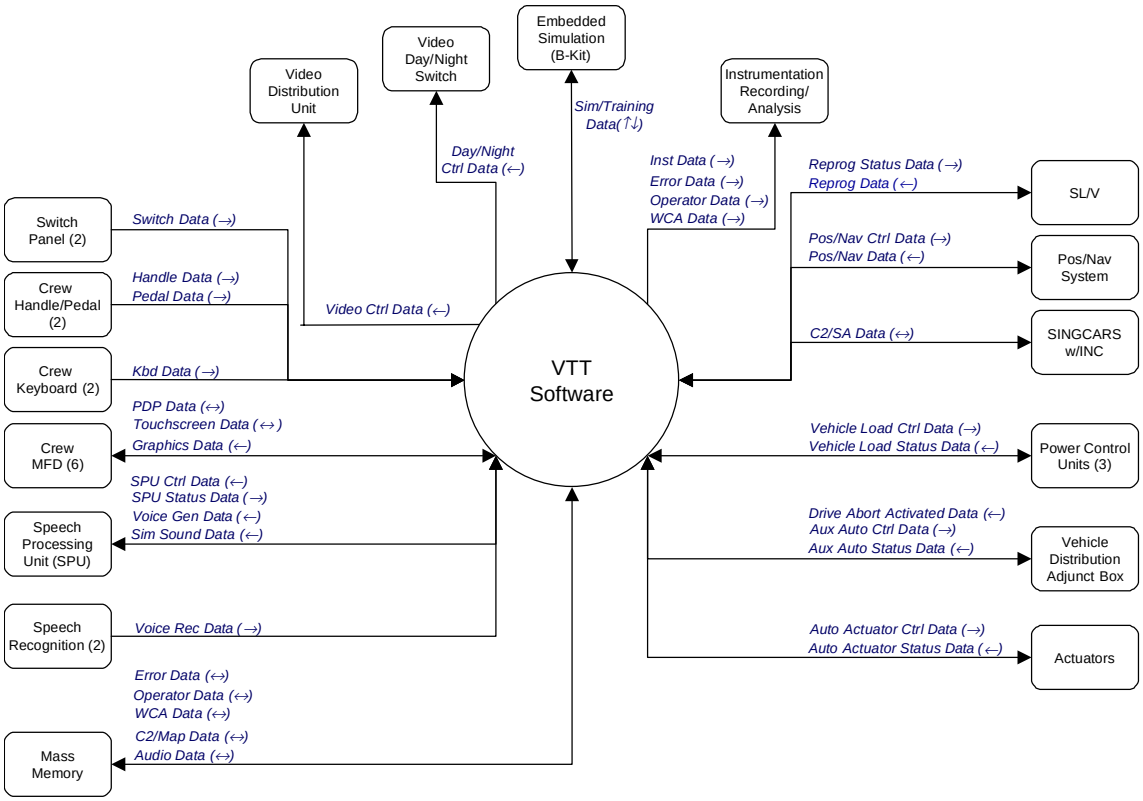

Table 2

| Data | Description | Representation |
|---|---|---|
| brake_cmd | Commanded percentage position for the brake actuator | 32-bit float |
| steering_cmd | Commanded percentage position for the steering actuator | 32-bit float |
| throttle_cmd | Commanded percentage position for the throttle actuator | 32-bit float |
| trans_gear_cmd | Commanded position for the transmission gear | enumeration |
| brake_pos_cmd | Commanded position of the brake actuator | 16-bit float |
| steering_pos_cmd | Commanded position of the steering actuator | 16-bit float |
| throttle_pos_cmd | Commanded position of the throttle actuator | 16-bit float |
| trans_fb_pos_cmd | Commanded position of the front/back actuator | 16-bit float |
| trans_ss_pos_cmd | Commanded position of the side/side actuator | 16-bit float |
| brake_status | Current percentage position of the brake actuator | 32-bit float |
| steering_status | Current percentage position of the steering actuator | 32-bit float |
| throttle_status | Current percentage position of the throttle actuator | 32-bit float |
| trans_gear_status | Current position of the transmission gear | enumeration |
| brake_pos_status | Current position of the brake actuator | 16-bit float |
| steering_pos_status | Current position of the steering actuator | 16-bit float |
| throttle_pos_status | Current position of the throttle actuator | 16-bit float |
| trans_fb_pos_status | Current position of the front/back actuator | 16-bit float |
| trans_ss_pos_status | Current position of the side/side actuator | 16-bit float |
| drive_abort_activated | Current drive abort state | enumeration |
| command_failed_id | Specifies what type of command failed | enumeration |
| command_failed_seq_num | Specifies which command had failed | 16-bit integer |
| drive_abort_activated_hi_lo | Current power state of the drive abort circuit | 16-bit integer |
| headlights_cmd | Commanded state of the headlights | enumeration |
| blackout_lts_cmd | Commanded state of the blackout lights | enumeration |

| | | |
|---|---|---|
| brake_lts_cmd | Commanded state of the brake lights | enumeration |
| smoke_gen_cmd | Commanded state of the smoke generator | enumeration |
| drive_image_select | Simulated commanded state of the drive sensor | enumeration |
| headlights_status | Current state of the headlights | enumeration |
| blackout_lts_status | Current state of the blackout lights | enumeration |
| brake_lts_status | Current state of the brake lights | enumeration |
| smoke_gen_status | Current state of the smoke generator | enumeration |
| system_voltage | Current output of the engine generator | 32-bit float |
| fuel_level | Current fuel level | 16-bit integer |
| eng_oil_pressure | Current engine oil pressure | 32-bit float |
| eng_coolant_temp | Current engine coolant temperature | 32-bit float |
| engine_status | Current engine running state | enumeration |
| vehicle_speed | Current vehicle speed | 32-bit float |
| odometer | Current odometer reading | 32-bit float |
| drive_image_status | Simulated state of the drive sensor | enumeration |
| headlights_status_hi_lo | Current power state of the headlights circuit | 16-bit integer |
| blackout_lts_status_hi_lo | Current power state of the blackout lights circuit | 16-bit integer |
| brake_lts_status_hi_lo | Current power state of the brake lights circuit | 16-bit integer |
| smoke_gen_status | Current power state of the smoke generator circuit | 16-bit integer |
| system_voltage_filtered | 25% of the voltage representing the system voltage | 16-bit float |

Table 2

## Conclusion

- By using the DOD TRM guidance document,TARDEC was able to identify interface classes that enable us to conduct architectural studies for the successful development of the VTT.
- The DOD TRM assisted in establishing common terms, interfaces, and service definitions in which to address interoperability issues and commonality via this singular framework.
- The benefit from using the DOD TRM in the creation of VOSA is best represented by the achievement of two fundamental categories: software portability and systems interoperability.
- The DOD TRM reference model was a useful tool in defining the analysis process for this study and it helped improve communication between members within VETRONICS.

- Addressing real-time interfaces was facilitated by the DOD TRM and its interface class definitions.
- This same VTT/TRM approach can be adapted to other military vehicles to expand and establish greater interoperability among operator stations across a wider range of military vehicles as well as air platforms (i.e., helicopters).
- Using the DOD TRM with other aids facilitates source selection in military procurements of this type as the TRM can be used as another parameter/metric to assess a contractor's approach and understanding of the problem.

**Reference:**


- Department of Defense Technical Reference Model, Version One, November 5, 1999
- Joint Technical Architecture, Version 2, November 15, 1999
- Software Requirements Specification for the VETRONICS Technologies Testbed, Version 2, September 22, 1999
- System Design Description for the VETRONICS Technologies Testbed, Draft Version 3, June 30, 1999
- System Specification for the VETRONICS Technologies Testbed, Version 3.1, August 31, 1999